(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
5 June 2003 (05.06.2003)

PCT

(10) International Publication Number
WO 03/046375 A1

(51) International Patent Classification[7]: F03B 13/26, 17/06

(21) International Application Number: PCT/EP02/12613

(22) International Filing Date:
12 November 2002 (12.11.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
MI2001A002505
29 November 2001 (29.11.2001) IT

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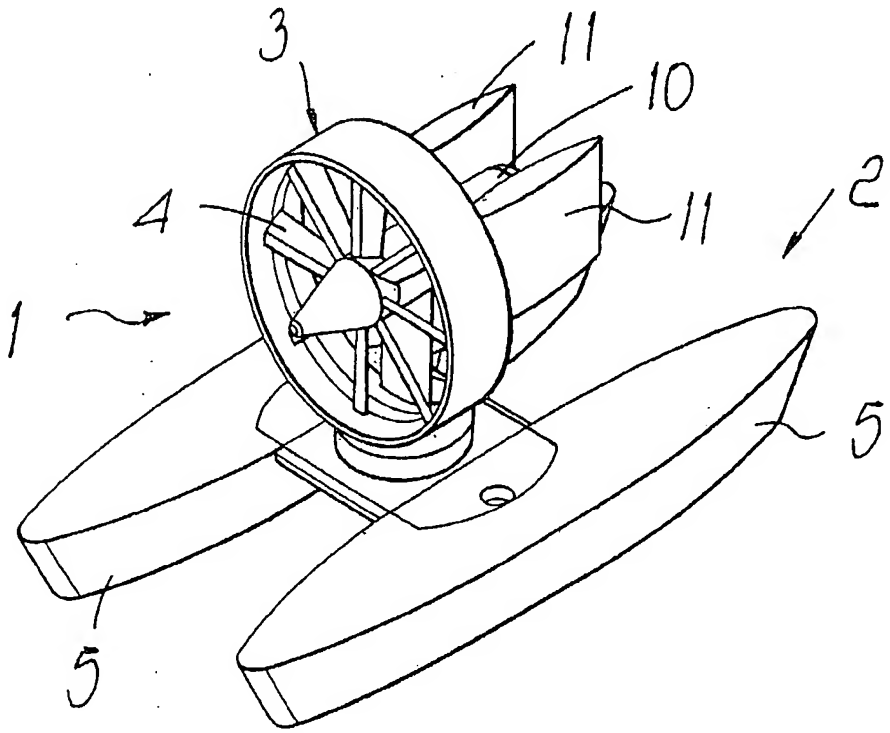
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SI, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

[Continued on next page]

(54) Title: SUBMERGED WATER CURRENT TURBINE



(57) Abstract: A power generating hydrodynamic apparatus comprising a supporting structure for a hydrodynamic motor which operates an electric current generator. The apparatus operates submerged, anchored to the seabed, utilizing the marine current, and the structure allows the apparatus to float and to submerge.

WO 03/046375 A1

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SUBMERGED WATER CURRENT TURBINE

The present invention relates to a hydrodynamic apparatus for generating power.

The interest for electric power stations that use so-called renewable energy sources is on the rise and many solutions for their utilization have been proposed.

In the field of the utilization of sea energy, tidal power stations that utilize tides have already been designed and built for many years, where tides are significant.

Also, many systems for utilizing wave motion or sea currents have also been proposed.

In particular, a system has been proposed which is constituted by a turbine that drives an electric generator and is associated with a support that is set on the seabed.

This type of system has drawbacks linked first of all to the well-known problems and costs of installing marine structures and also to the fact that the apparatus must be designed expressly for a very specific location, because the characteristics of marine currents are particular and specific for each site.

Another very important problem in the case of fixed marine structures is the vulnerability of those structures to the elements and to events such as seaquakes, earthquakes, et cetera, which in some locations are not at all rare and can damage the structure irreparably or require expensive repairs.

The aim of the present invention is to provide a hydrodynamic apparatus for generating power that overcomes the drawbacks of the cited prior art.

An object of the invention is to provide a hydrodynamic apparatus for generating power that is versatile and can be used in locations that can have very different characteristics.

An important object of the invention is to provide a hydrodynamic apparatus for generating power whose installation is substantially easier and cheaper than conventional apparatuses.

Another object of the invention is to provide an apparatus that is capable of

withstanding particular and violent environmental conditions.

Another object is to provide an apparatus with modular characteristics that can be used for a wide range of electric power stations, with very different electric power outputs.

This aim, these objects and others that will become better apparent hereinafter are achieved by a hydrodynamic apparatus for power as claimed in the appended claims.

Further characteristics and advantages will become better apparent from the description of preferred but not exclusive embodiments of the invention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

FIG. 1 is a schematic perspective view of the apparatus according to the invention;

FIG. 2 is a front elevation view of the apparatus according to the invention;

FIG. 3 is a side elevation view of the apparatus according to the invention;

FIG. 4 is a plan view of the apparatus according to the invention;

FIG. 5 is a perspective view of the apparatus, shown in the condition for transportation or navigation;

FIG. 6 is a front elevation view of the apparatus, shown in the condition for transportation or navigation;

FIG. 7 is a perspective view of the apparatus shown in the operating condition, anchored to the seabed;

FIG. 8 is a plan view of the apparatus shown in the operating condition, anchored to the seabed;

FIG. 9 is a schematic view of an electric power station that uses apparatuses according to the invention;

FIG. 10 is a perspective view of an embodiment of a hydrodynamic motor having a double impeller;

FIG. 11 is a side section view of the hydrodynamic motor of the preceding figure;

FIG. 12 is a perspective view of the apparatus, according to a further aspect of the invention;

FIG. 13 is a perspective view of the apparatus, according to still a further aspect of the invention.

With reference to the above figures, the apparatus according to the invention, generally designated by the reference numeral 1, comprises a supporting structure 2 for a hydrodynamic motor 3 which drives an electric current generator 10.

The hydrodynamic motor comprises a turbine that has an impeller with adjustable vanes 4 and is moved by the marine current in order to drive the electric current generator. The vanes of the impeller are adjustable, namely the pitch of the vanes is adjustable.

The hydrodynamic motor is associated with the supporting structure through an articulated coupling 12, which allows to adjust the inclination of the motor so that, for example when moving the apparatus, the motor can be tilted in order to reduce bulk and aerodynamic drag, as shown in FIG.s 5 and 6.

The turbine is provided with refinements to ensure its hydrodynamic efficiency in relation to the required energy production and, in addition to the mentioned vane adjustment, which can be performed automatically according to the intensity of the marine current, it is ducted and provided with hydrodynamic appendages 11 that facilitate the correct orientation of the turbine following variations in the direction of the marine current.

FIGs. 10 and 11 show an hydrodynamic motor 103 comprising a turbine having two impellers 104 and 144 rotating in opposite directions.

The first impeller 104 generates a flow which is oriented and can be exploited by the second impeller 144.

The impellers 104 and 144 are ducted and mounted on a vertical mount which is able to rotate in order to allow the motor to orientate itself according to the direction of the water current.

An apparatus provided with the double turbine describe above may have a

power output of 2000 kW with a 2 knot marine current. A reduced mechanical efficiency, due to the double impeller, is more than compensated by the higher power output which doubles the power output of a single impeller motor.

The supporting structure 2 allows the apparatus both to float and to submerge.

For this purpose, the supporting structure 2 comprises one or more tanks, or floaters 5 which, in the illustrated example, are two and keel-shaped, constituting in practice a catamaran structure.

The tanks 5 can include their own propulsion means, such as propulsion and steering propellers, designated respectively by the reference numerals 6 and 7, or can be towed both on the surface and underwater, according to requirements.

The supporting structure further includes an anchoring means, which is constituted, in the specific case, by articulated excavation units 8 which are actuated hydraulically.

The articulated excavation units 8, which are not rigid and allow motion compensation, are adapted to anchor the structure to the seabed 9 in the position chosen for the installation of the apparatus.

The apparatus according to the invention can be effectively employed in an electric power station constituted by a plurality of submerged apparatuses which are connected to a land-based station 13, as shown schematically in FIG. 9, by means of conducting cables 14.

The apparatuses, whose number and arrangement is variable according to specific requirements, are assembled and completed and then towed to the immersion site. For the immersion, the tanks are flooded, in a per se known manner, and the apparatus can be towed to the installation site, where it is anchored by way of the anchoring means.

During immersion, the apparatus can be remote-controlled from the surface and can move by using its own propulsion means to the anchoring point, where the anchoring means is actuated, again by remote control.

FIG. 12 shows an apparatus 101, according to a further aspect of the invention, comprising a supporting structure 102 constituted by tanks, or floaters 105 which, in the illustrated example, are two and keel-shaped, constituting in practice a catamaran structure.

The supporting structure 102 is provided with its own propulsion means, constituted by tracks, or crawlers, 106, that allow the structure to move on the ground or bottom.

The supporting structure 102 further includes an anchoring means, which is constituted, in the specific case, by articulated excavation units 108 which are actuated hydraulically, as described above.

FIG. 13 shows an apparatus 201, according to a further aspect of the invention, wherein the supporting structure 202 is a trimaran structure provided with two side floaters 205 and a center floater 255.

The supporting structure 202 may support a number of hydrodynamic motors 3 or 103.

A battery of five hydrodynamic motors 3, 103, as in the illustrated example, may have a power output between 50000 and 60000 kW.

In practice, it has been found that the invention achieves the intended aim and objects, an apparatus having been provided which can be installed without working underwater, thus avoiding the dangers and costs linked to human underwater work.

The apparatus is particularly advantageous also because it is virtually insensitive to weather and geologic events; any seismic movements of the seabed can in fact be compensated by the particular supporting structure, which is simply rested on the seabed, and by the anchoring means.

An advantage of the invention, especially when the apparatus is installed at great depth, is that the apparatus can be made to resurface in order to work on the surface for maintenance and extraordinary interventions.

In order to adjust the position of the turbine, in relation to variations in the intensity and direction of the currents, it is possible to use systems that are

already known in the art.

This adaptability ensures maximum efficiency of the system in any environmental condition and, together with its modular nature, allows to use the apparatus in sites with even very different environmental conditions (for example even rivers and canals), simply by varying the number of submerged apparatuses and their arrangement according to specific requirements.

The apparatus according to the invention is susceptible of numerous modifications and variations, within the scope of the appended claims; all the details may be replaced with other technically equivalent elements.

The materials used, as well as the dimensions, may of course be any according to requirements and to the state of the art.

CLAIMS

1. A hydrodynamic apparatus for generating power, comprising a supporting structure for a hydrodynamic motor operating an electric current generator, characterized in that the apparatus operates submerged, anchored to the seabed, utilizing the marine current, and in that the structure allows the apparatus to float and to submerge.

2. The apparatus according to claim 1, characterized in that said hydrodynamic motor comprises a turbine having an impeller with adjustable vanes and is driven by the marine current in order to actuate said electric current generator.

3. The apparatus according to one or more of the preceding claims, characterized in that said vanes are provided with a device for dynamically adjusting the pitch angle of said vanes as a function of the speed of the flow of the marine current.

4. The apparatus according to claim 1 or 2, characterized in that said hydrodynamic motor is associated with the supporting structure by means of an articulated coupling for adjusting of the inclination of the motor.

5. The apparatus according to one or more of the preceding claims, characterized in that said hydrodynamic motor is associated with the supporting structure so that it can rotate about it in order to catch the maximum thrust cross-section of the currents.

6. The apparatus according to one or more of the preceding claims, characterized in that said turbine has two impellers rotating in opposite directions.

7. The apparatus according to one or more of the preceding claims, characterized in that said turbine is ducted and has hydrodynamic appendages adapted to facilitate the correct orientation of the turbine following variations in the direction of the marine current.

8. The apparatus according to one or more of the preceding claims, characterized in that said supporting structure comprises one or more keel-shaped tanks.

9. The apparatus according to one or more of the preceding claims, characterized in that said supporting structure comprises is self propelled.

10. The apparatus according to claim 9, characterized in that said supporting structure comprises propulsion and steering propellers.

11. The apparatus according to claim 9, characterized in that said supporting structure comprises track or crawler adapted to move said structure on the ground or seabed.

12. The apparatus according to one or more of the preceding claims, characterized in that said supporting structure comprises an anchoring means adapted to anchor said structure to the seabed.

13. The apparatus according to one or more of the preceding claims, characterized in that said anchoring means comprises articulated excavation units which are actuated hydraulically.

14. The apparatus according to one or more of the preceding claims, characterized in that said articulated excavation units are not rigid and can compensate motion.

15. An electric power station, comprising one or more hydrodynamic apparatuses generating electric current, which are submerged and connected to a land-based station, characterized in that each one of said apparatuses comprises a supporting structure for a hydrodynamic motor operating an electric current generator and is characterized in that said apparatus works while submerged, anchored to the seabed, utilizing the marine current, and in that the structure allows the apparatus to float and to submerge.

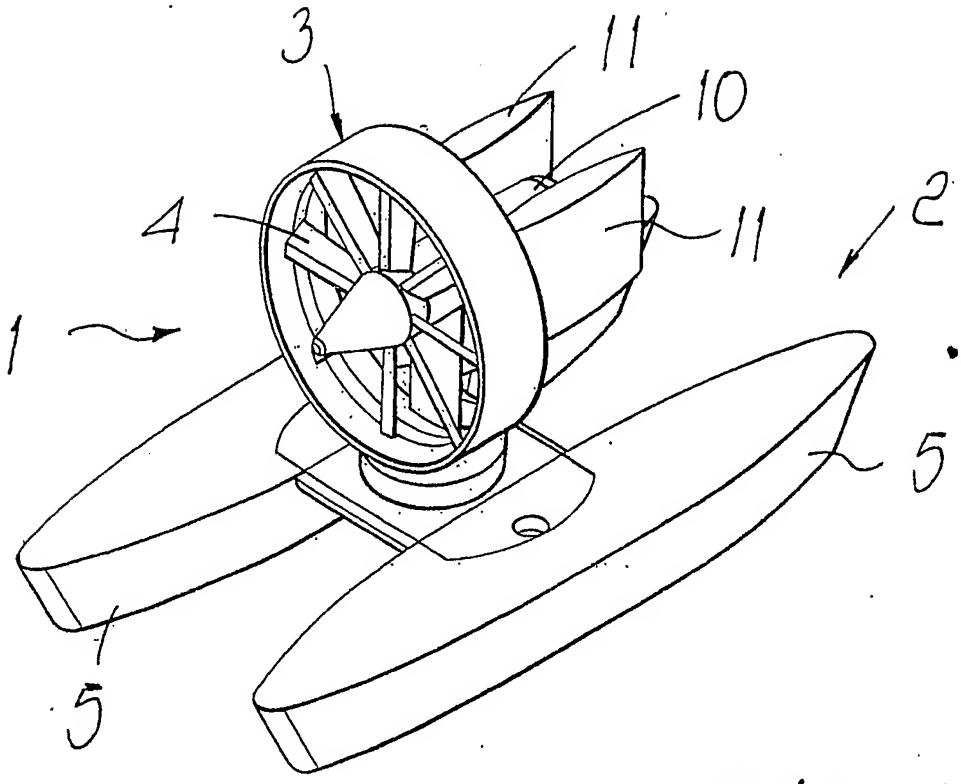


Fig. 1

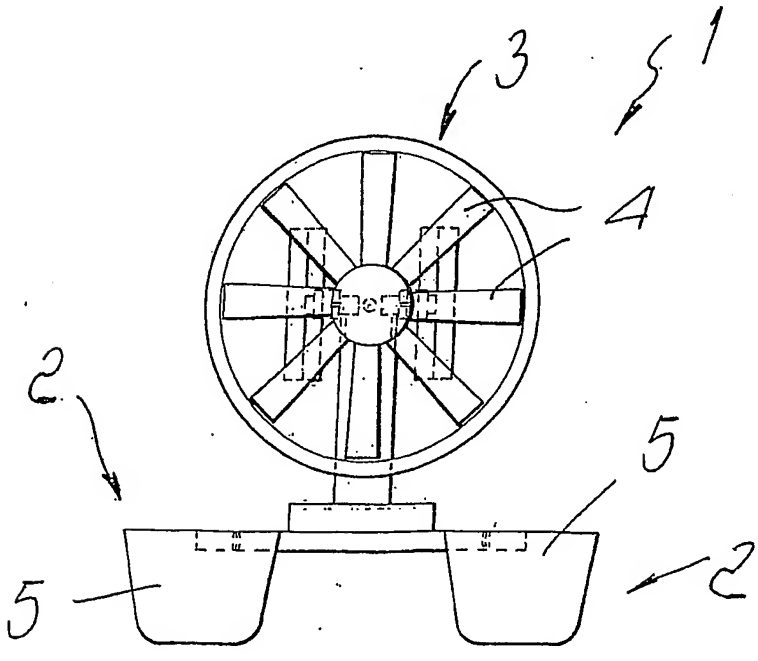


Fig. 2

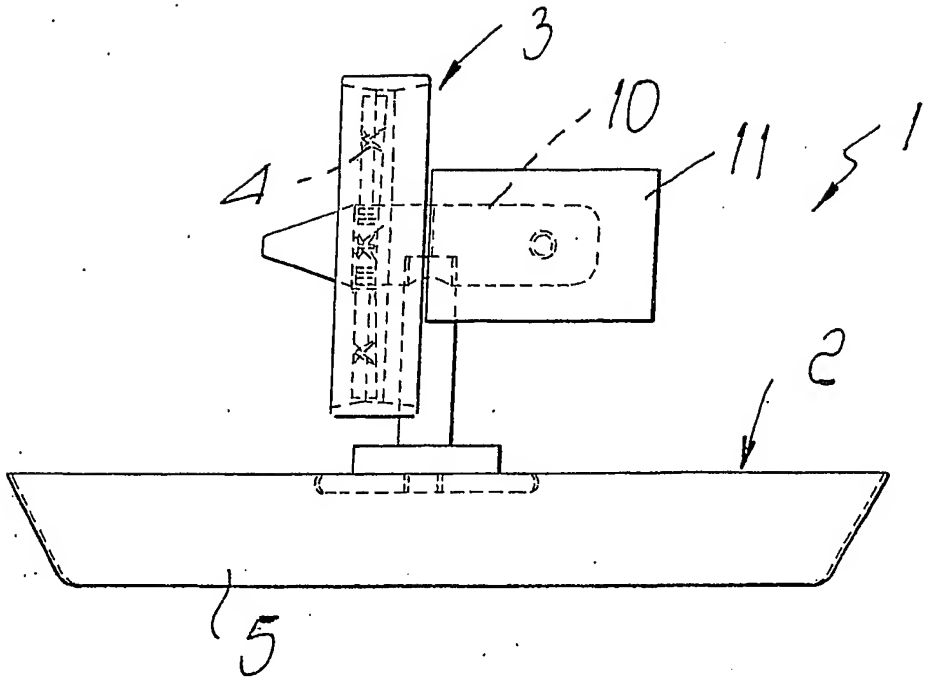


Fig. 3

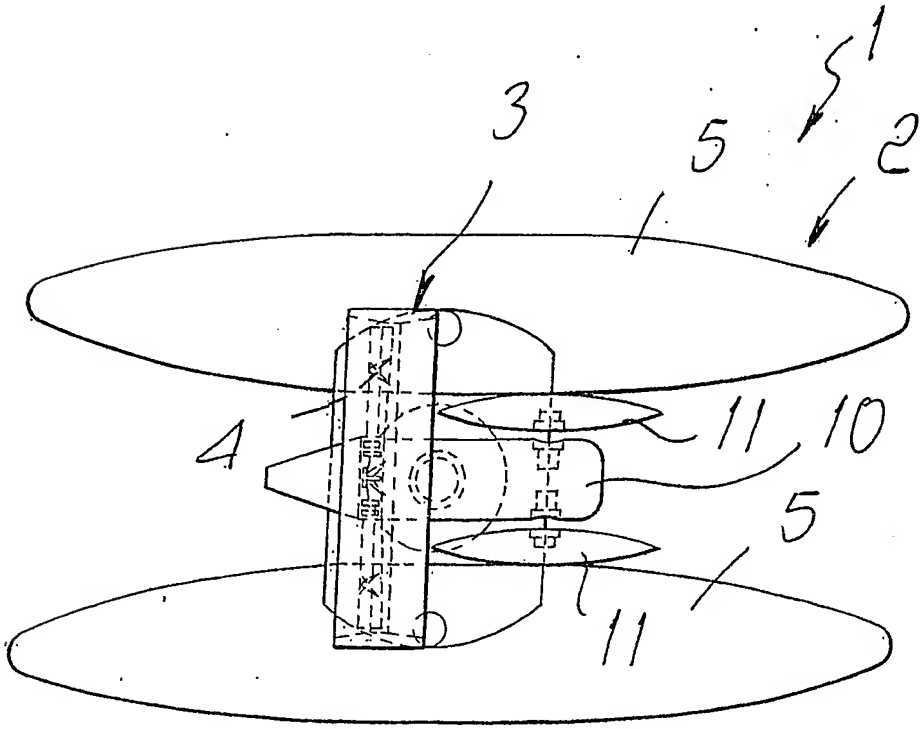


Fig. 4

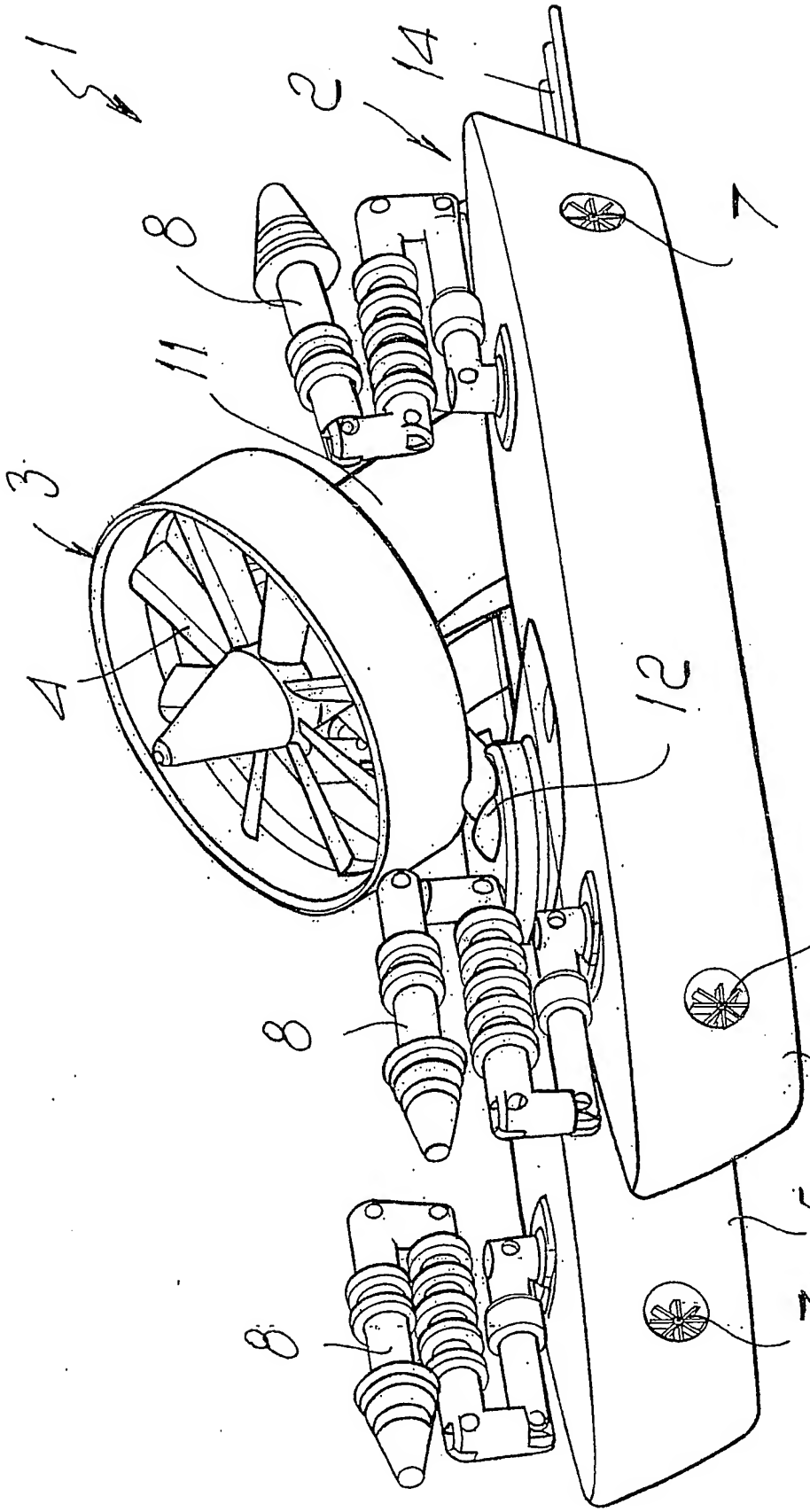
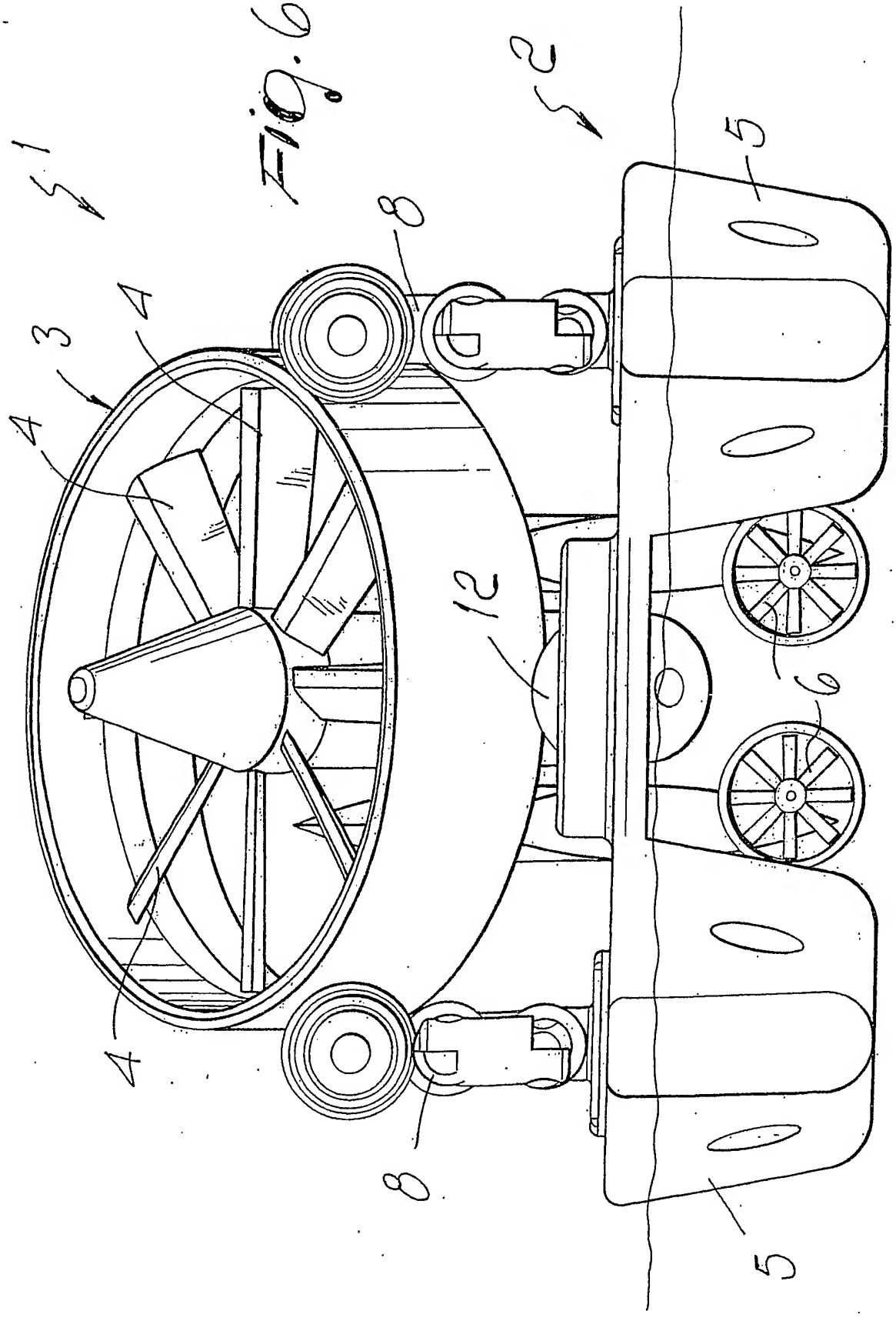


Fig. 5

Fig. 6



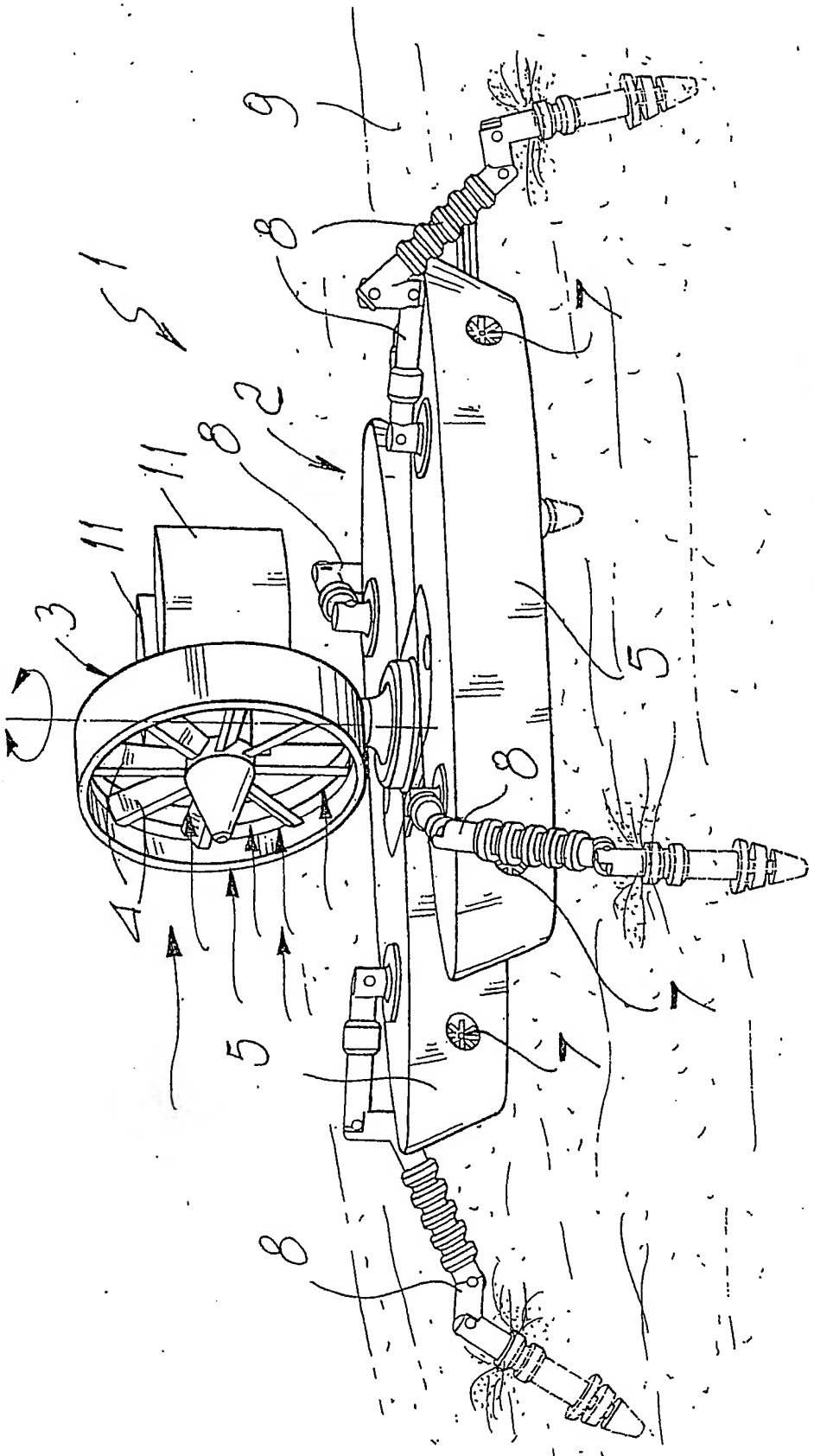


Fig. 1

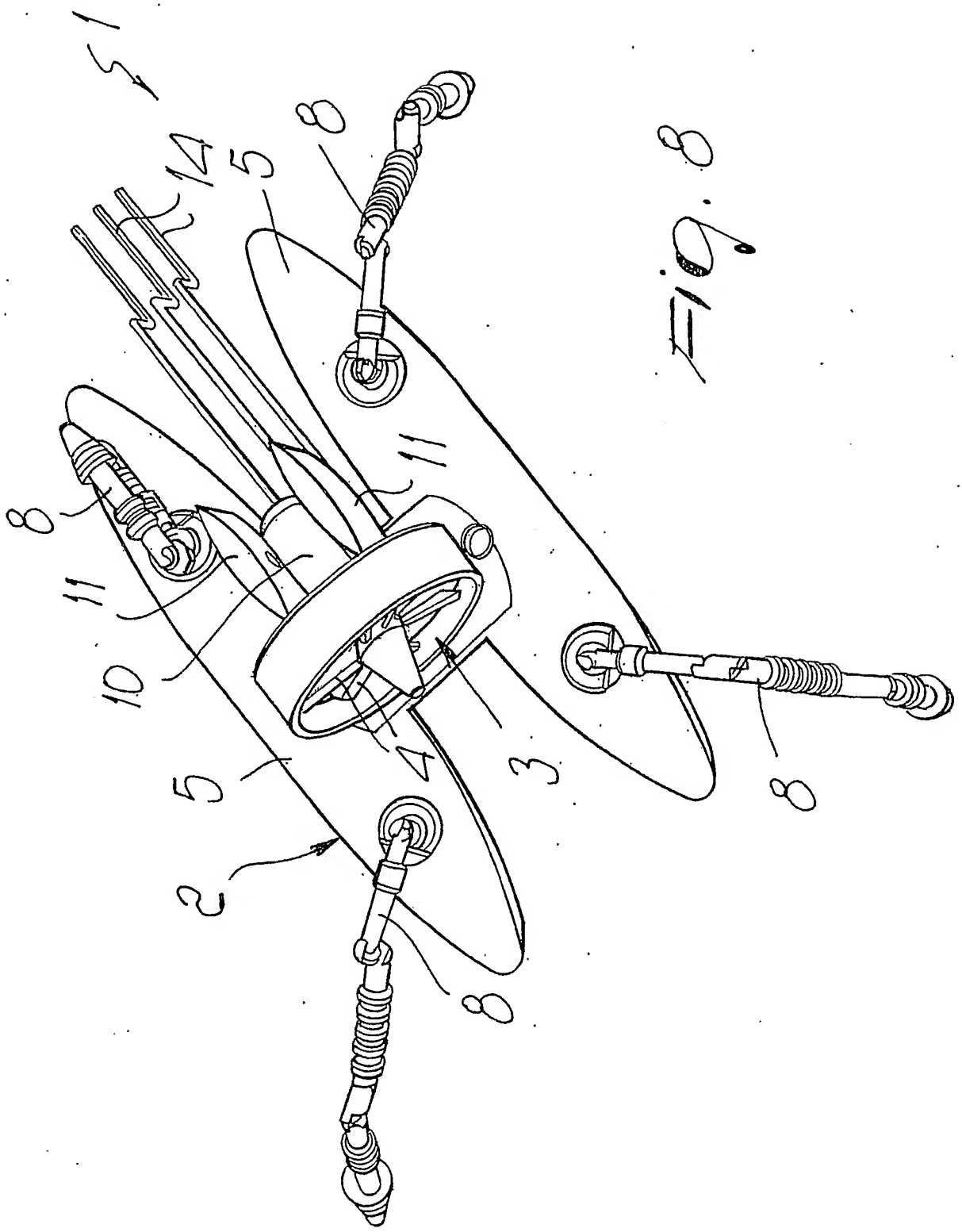


Fig. 8

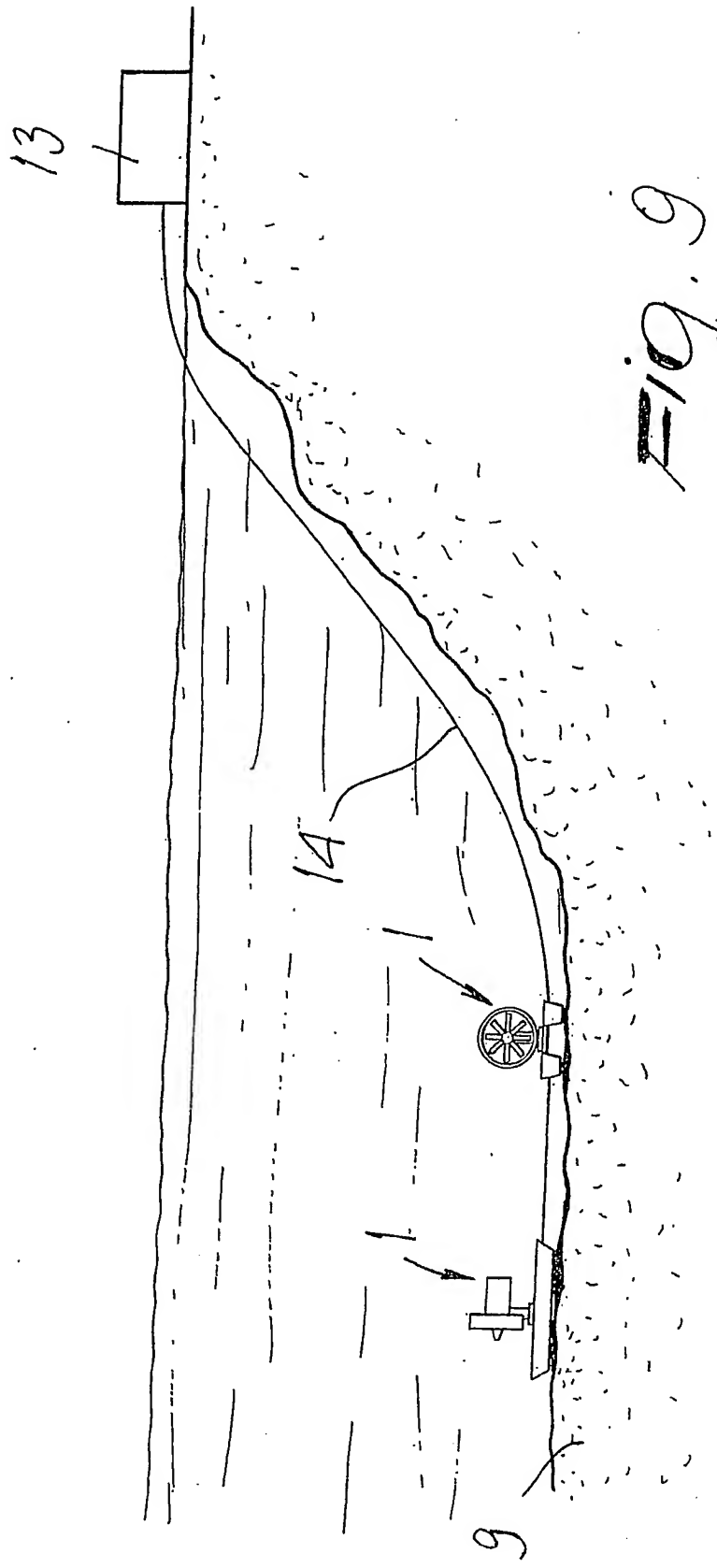


Fig. 9

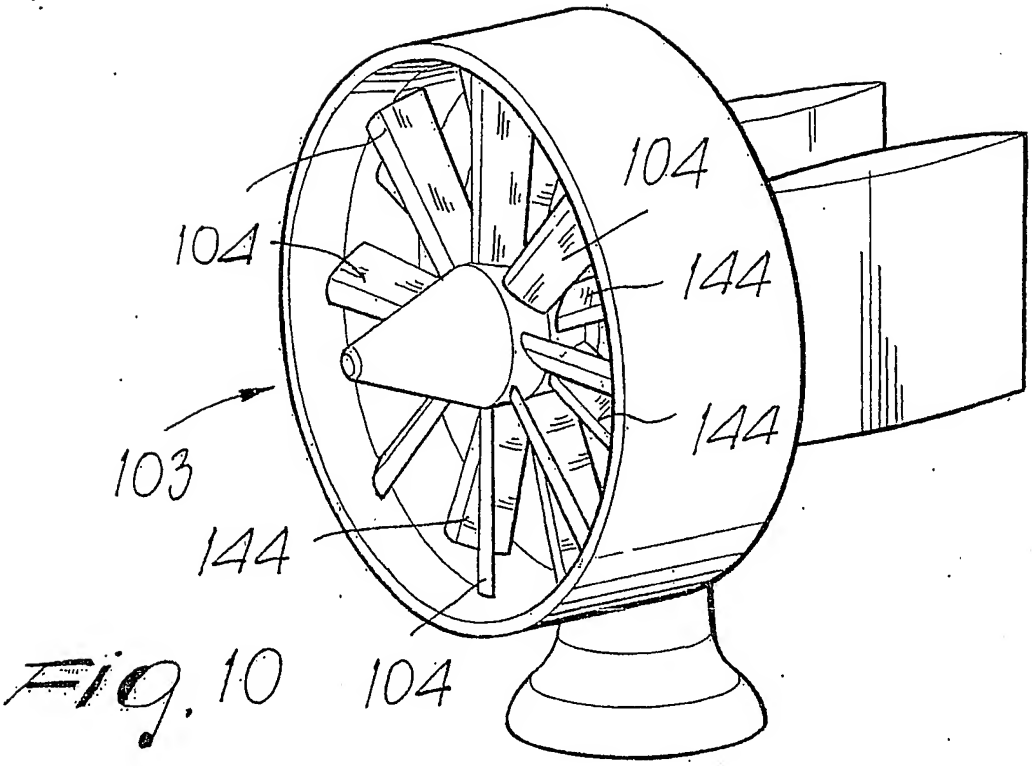


Fig. 10

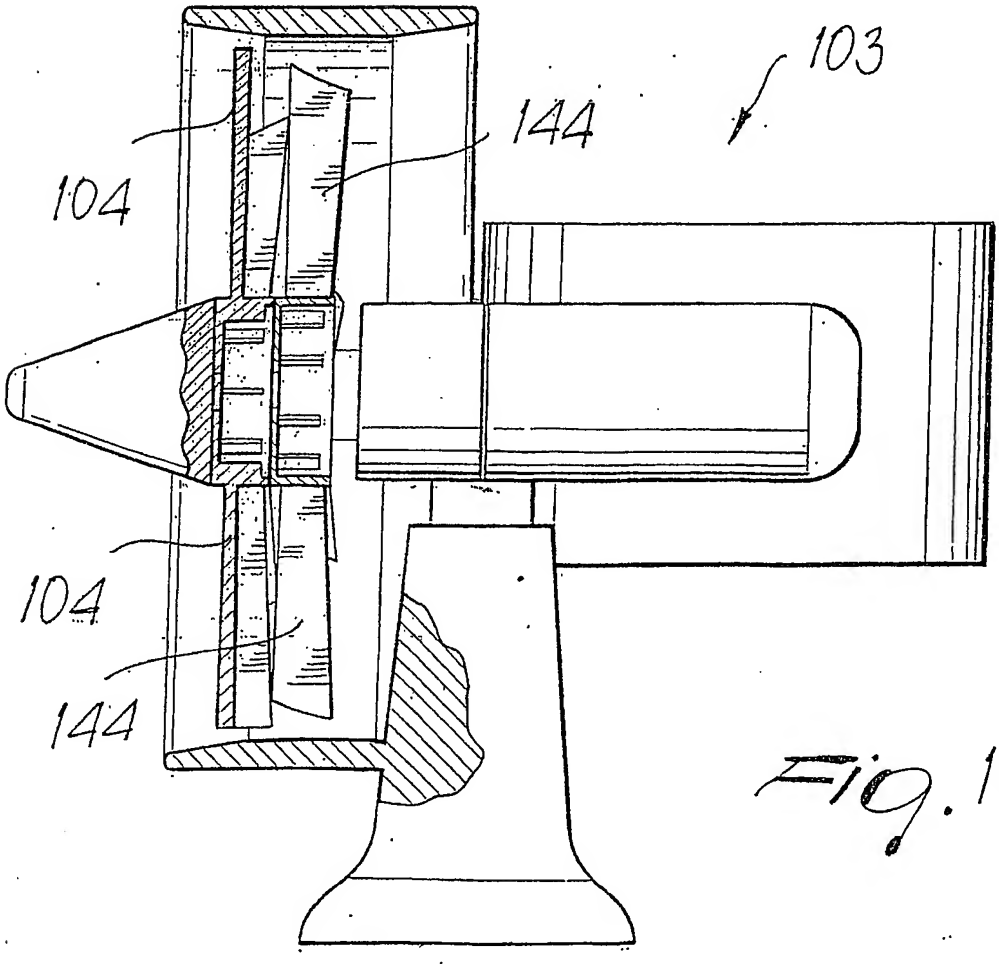


Fig. 11

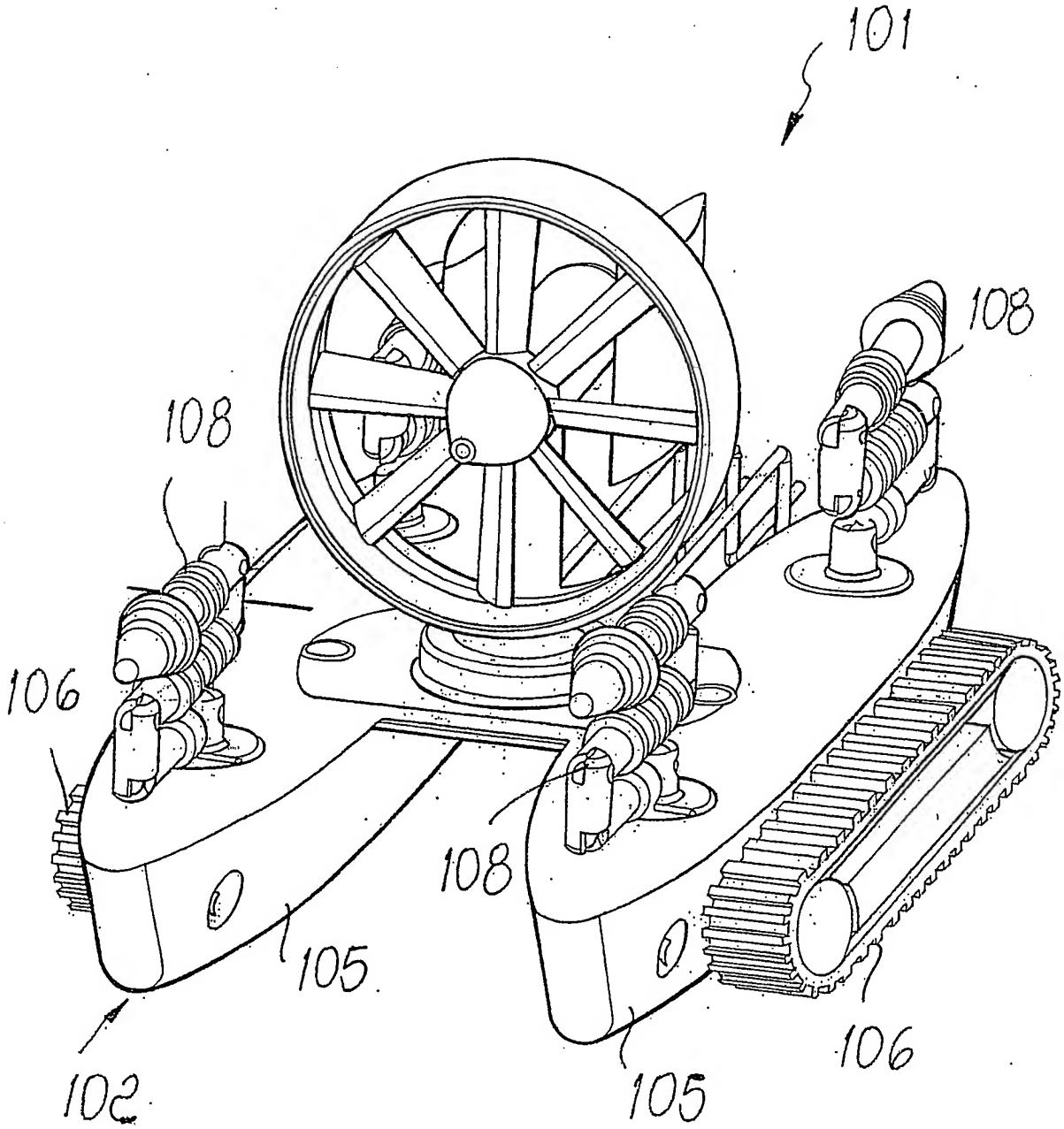


Fig. 12

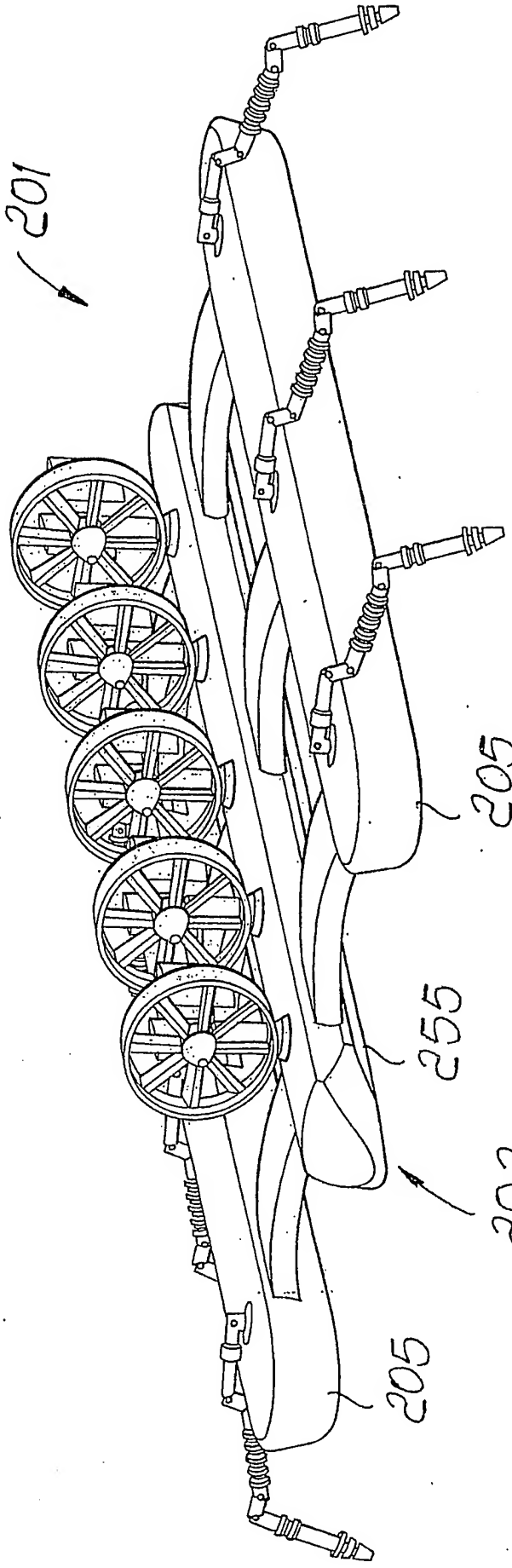


Fig. 13

INTERNATIONAL SEARCH REPORT

Internation: lication No
PCT/EP 02/12613

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F03B13/26 F03B17/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	DE 199 48 198 A (WOBBEN ALOYS) 26 April 2001 (2001-04-26) abstract column 1, line 43 - line 50 column 1, line 62 - line 64 column 1, line 68 -column 2, line 14	1,7,12, 15
Y		2,3
Y		4,5
Y		6
Y		8-10
Y		11
Y		13,14
Y	US 4 095 918 A (MOUTON JR WILLIAM J ET AL) 20 June 1978 (1978-06-20) column 7, line 63 - line 65 claim 9	2,3

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 February 2003	27/02/2003
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Criado Jimenez, F

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PCT/EP 02/12613

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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